Pr.6505

INSTITIÚID ÁRD-LÉINN BHAILE ÁTHA CLIATH
(Dublin Institute for Advanced Studies)

Annual Report of the work of the Institute and its Constituent Schools presented by the Council to the Minister for Education in respect of the Financial Year 1960-61

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Annual Report of the work of the Institute and its Constituent Schools presented by the Council for the Financial Year 1960-61

In accordance with the provisions of Section 29 of the Institute for Advanced Studies Act, 1940 (No.13 of 1940), the Council of the Institute has the honour to present to the Minister for Education for submission to the Government a report of the work and activities of the Institute and its Constituent Schools for the financial year ending 31st March, 1961.

The general purpose which it is hoped to accomplish is clearly stated in the Act establishing the Institute, namely, the Institute for Advanced Studies Act, 1940 (No.13 of 1940) and in the Establishment Orders establishing the three Constituent Schools, namely, the Institute for Advanced Studies (School of Celtic Studies) Establishment Order, 1940, the Institute for Advanced Studies (School of Theoretical Physics) Establishment Order, 1940, and the Institute for Advanced Studies (School of Cosmic Physics) Establishment Order, 1947, and need not be referred to here. It is deemed desirable, however, to include in the report for the purposes of record certain particulars about the constitution of the Council of the Institute and the membership of the Governing Boards of the three Constituent Schools on the 31st March 1961.

The report is presented under the following principal heads:-

I - Constitution of the Council of the Institute and of the Governing Boards of the three Constituent Schools on the 31st March, 1961.

II - Report of the Governing Board of the School of Celtic Studies.

III - Report of the Governing Board of the School of Theoretical Physics.

IV - Report of the Governing Board of the School of Cosmic Physics.

I - Constitution of the Council of the Institute and of the Governing Boards of the three Constituent Schools on the 31st March 1961.

1. THE COUNCIL OF THE INSTITUTE

Chairman:

Professor Edward J. Conway, M.D., D.Sc., F.R.S., F.R.C.P.I.

Ex-Officio Members:

Dr. Michael Tierney, M.A., D.Litt., President, University College, Dublin; Dr. Albert J. McConnell, M.A., M.Sc., Sc.D., Provost, Trinity College, Dublin; Professor John L. Synge, M.A., Sc.D., F.R.S.C., F.R.S., President, Royal Irish Academy.

Members appointed by the Governing Boards of the Constituent Schools:

Right Reverend Monsignor Patrick Boylan, D.D., M.A., D.Litt.; Professor Myles Dillon, M.A., Ph.D.; Professor Felix E. W. Hackett, M.A., M.Sc., Ph.D.; Professor John L. Synge, M.A., Sc.D., F.R.S.C., F.R.S.; Professor John H. J. Poole, M.A., B.A.I., Sc.D.; Professor M. A. Ellison, D.Sc.

2. THE GOVERNING BOARD OF THE SCHOOL OF CELTIC STUDIES

Chairman:

Right Reverend Monsignor Patrick Boylan, D.D., M.A., D.Litt.

Senior Professors:

Michael A. O'Brien, M.A., Ph.D.; Daniel A. Binchy, M.A., Ph.D., B.L.; Myles Dillon, M.A., Ph.D.

Appointed Members:

Miss Áine de Paor, M.A., Ph.D.; Reverend John Ryan, S.J., M.A., D.Litt.; Reverend Francis Shaw, S.J., M.A.; Éamonn Mac Giolla Iasachta, M.A., D.Litt.; Ernest Gordon Quin, M.A., F.T.C.D.; Tomás de Bhaldraithe, M.A., Ph.D., D.Litt., M.R.I.A.

3. THE GOVERNING BOARD OF THE SCHOOL OF THEORETICAL PHYSICS

Chairman:

Felix E. W. Hackett, M.A., M.Sc., Ph.D.

Senior Professors:

John L. Synge, M.A., Sc.D., F.R.S.C., F.R.S.; Cornelius Lanczos, Ph.D.

Appointed Members:

Albert J. McConnell, M.A., M.Sc., Sc.D.; George R. Keating, M.Sc.; Thomas S. Wheeler, Ph.D., D.Sc., F.R.C.Sc.I.; Reverend James R. McConnell, D.Sc.; Máirtín Ó Tnúthail, D.Sc.; Patrick Quinlan, B.E., M.Sc., Ph.D.; David R. Bates, D.Sc., F.R.S.

4. THE GOVERNING BOARD OF THE SCHOOL OF COSMIC PHYSICS

Chairman:

John H. J. Poole, M.A., B.A.I., Sc.D.

Senior Professors:

Leo W. Pollak, Ph.D.; Cormac Ó Ceallaigh, M.Sc., Ph.D.; Mervyn A. Ellison, D.Sc.

Appointed Members:

Eric M. Lindsay, M.A., M.Sc., Ph.D.; Reverend Patrick J. I. McLaughlin, D.Sc.; Thomas Edwin Nevin, D.Sc.; Patrick J. Nolan, Ph.D., D.Sc.; Mariano Doporto, D.Phys.Sc.; John J. McHenry, M.A. (Cantab.), D.Sc., F.Inst.Phys.; Cilian Ó Brolcháin, M.Sc.; Ernest T. S. Walton, M.A., M.Sc., Ph.D., F.T.C.D.; Thomas S. Wheeler, Ph.D., D.Sc., F.R.C.Sc.I.; Cyril F. G. Delaney, M.A., Ph.D.

5. ADMINISTRATIVE STAFF

Registrar:

Patricia O'Neill.

Senior Clerk:

Maura Devoy, B.A.

Clerks:

Mary A. O'Rourke, B.A.; Janet Dowling.

II - Report of the Governing Board of the School of Celtic Studies adopted at its meeting on 4th July, 1961.

1. STAFF, SCHOLARS AND EXTERN RESEARCH WORKERS

Senior Professors:

Myles Dillon, Director of the School; Michael A. O'Brien; Daniel A. Binchy.

Professors:

James P. Carney; Miss Cecile O'Rahilly.

Assistant Professor:

Rev. Cuthbert McGrath, O.F.M.

Assistant (Part-time):

Mrs. Nessa Doran.

Research Associates:

Heinrich Wagner; Liam Price.

Technical and Clerical Staff:

Miss Máire Breatnach; Máire Bean Uí Chinnsealaigh (appointed 1 October 1960).

Scholars:

Louis Paul Nemo (Roparz Hemon); Máire Ní Cheallacháin; Richard A.Q. Skerrett (entered 1 January 1961).

Visiting Scholars:

Morfydd E. Owen; Rolf Baumgarten.

Extern Research Workers commissioned by the School:

Rev. Anselm Faulkner, O.F.M.; Rev. Pádraig Ó Súilleabháin, O.F.M.; Rev. Bartholomew Egan, O.F.M.; Dr. R. B. Breatnach; Professor Nils Holmer; Dr. L. Bieler; Professor Idris Foster; Lil Nic Dhonnchadha; Gordon Mac Lennan; Professor Simon Evans.

2. RESEARCH

Professor O'Brien completed revision of proofs of Volume IV of the Book of Leinster which is now ready for printing off. Continued revision of Volume V of the same work and transcribed some of Volume VI. Volume V is now ready for the printer. Finished checking proofs of his Corpus of Irish Genealogies (Vol.I) and prepared an Introduction and list of Corrigenda. Continued work on Volumes II and III. He prepared two articles on various problems of Celtic Philology to appear in Celtica.

Professor Binchy completed 800 folios of manuscript for the first volume of Corpus Iuris Hibernici and these were sent to the printer. Proofs of nearly half of the 'copy' submitted have been received. He continued transcription of Irish legal manuscripts. The final proofs of Scéla Cano Maic Gartnáin, for publication in the Mediaeval and Modern Irish Series, were revised and passed for press. Professor Binchy edited and sent to press Volume XIX of Ériu and contributed two articles. His article on 'Indo-European *$g^{u}e$ in Irish' appeared in Celtica V. He also completed an Appendix for The Celtic Penitentials, Vol.V Scriptores Latini Hiberniae, edited by Dr. L. Bieler.

Professor Dillon completed the appendixes to the Book of Rights and supplied indexes. The book is now in its final stage. Nāṭakalakṣaṇaratnakósa II appeared during the year (edited in collaboration with Professor Fowler and Professor Ragahavan). Celtica V was also published. The Modern Irish Grammar and Reader was revised in galleys and in page-proof and will appear shortly. Field work for the Linguistic Survey was done in East Galway and North Clare in collaboration with Mr. Ciarán Bairéad. A seminar on the Lebor Gabála was held in the Hilary Term.

Professor Carney continued work on the Patrician Problem and his book on this matter was passed for press. He supervised and gave advice to Mrs. Nessa Doran in the preparation of her Catalogue of Irish Manuscripts in the National Library.

Professor O'Rahilly worked on the final proofs of her edition of the Stowe version of Táin Bó Cuailnge. An edition of Cath Fionntrágha for the Mediaeval and Modern Irish Series was in course of preparation. Professor O'Rahilly supervised excerptions for the Dictionary of Classical Modern Irish.

Rev. Cuthbert McGrath, O.F.M. submitted the first instalment of the second volume of Dán na mBráthar Mionúr which was ready for printing. Work progressed on articles dealing with sources containing biographical material on Irish saints for the Enciclopedia Agiografica and 150 folios of manuscript have already been sent off for publication. An article on The preterite passive plural in Bardic poetry has been revised with a view to its publication in Éigse. Fr. McGrath supervised work on the series of Franciscan Texts.

Mrs. Nessa Doran continued work on the Catalogue of Irish Manuscripts in the National Library and proofs of the second fasciculus containing MSS. Nos. 15 - 69 were passed for press. The non-medical manuscripts in the collection of vellum mss. (Nos.1-7, 9, 10 and 14) were catalogued.

Professor Heinrich Wagner was preparing the first fasciculus of the second volume of the Linguistic Atlas and Survey of Irish Dialects.

Mr. Liam Price has made further progress on the archive of Irish place-names and approximately 24,000 to 25,000 cards have now been made.

M. Hemon worked on an edition of three Middle Breton poems, preparation of which was completed at the end of the period under review. Of his Historical Dictionary of Breton one volume (B, and beginning of C) appeared during the year and another volume (end of C, and beginning of D) will appear this summer.

Máire Ní Cheallacháin continued her work for the Dictionary. Her edition of poems by Aodhagán Ó Raithile is nearing completion. She has also begun to transcribe the short text of Lebor Gabála Brenn from the Liber Flavus. She attended Professor Dillon's course in Middle Irish and lectures at University College.

Richard Skerrett worked on the preparation for publication of a fifteenth century Irish text. He did some excerpting for the Dictionary of Classical Modern Irish and assisted in editing slips for the Royal Irish Academy Contributions to a Dictionary of the Irish Language. He attended Professor Dillon's weekly seminar and at the end of the year went to Cor na Rón, Co. Galway to study the spoken Irish and collect material of folklore interest with the aid of a tape-recorder.

Rev. Anselm Faulkner, O.F.M. continued work on An Bheatha Chrabhaidh and An Sgathán Spioradálta.

Rev. Pádraig Ó Súilleabháin, O.F.M. corrected and sent in proofs of the Notes and Glossary to Lucerna Fidelium and completed work on the Preface.

Rev. Bartholomew Egan, O.F.M. worked on the Notes to Graiméir Ghaeilge na mBráthar Mionúr, the text of which is in paged-galleys.

Dr. R. B. Breatnach worked on the final proofs of Seana-Chaint na nDéise II which was passed for press. He spent two short periods in Co. Waterford working on the morphology of the dialect.

Professor Nils Holmer commenced checking first proofs of the Gaelic of

Kintyre.

Dr. L. Bieler completed preparation of Volume V of the Scriptores Latini Hiberniae series (The Celtic Penitentials) which was sent to press. Proofs of more than half of the work have been received and, despite the great delay at the printers, it is expected to appear before the end of 1961.

Professor Idris Foster has almost completed his edition of Kulhwch ac Olwen for the Mediaeval and Modern Welsh Series. The manuscript is promised for the summer of 1961.

Lil Nic Dhonnchadha prepared an edition of Aided Muirchertaig Meic Erca for the Mediaeval and Modern Irish Series and did some excerpting for the Dictionary of Classical Modern Irish.

Mr. Gordon Maclennan prepared for publication a text-book on Scottish Gaelic entitled Gaidhlig Uidhist a Deas.

Professor Simon Evans checked the first proofs of his Grammar of Middle Welsh for publicstion in the Mediaeval and Modern Welsh Series.

The two projects mentioned in the last Report have made further progress.

Dictionary of Modern Irish: During the year work on the material for a dictionary of Modern Irish from written sources was continued. Máire Ní Cheallacháin excerpted Tiomna Nuadh ar dTighearna (Ó Domhnuill, 1602), Tiomna Nuadh ár dTighearna (Ó Cathán, 1858) and Érise, Vols.I - IX. Mr. Skerrett has in part excerpted Irish Grammatical Tracts III (ed. Bergin). Lil Nic Dhonnchadha has completed work on Fíorthairbhe na nGaoidheal (Richardson, 1716).

Following discussion between the Director and the joint-editors it was agreed that excerpting would be mainly from material from the period c. 1550 - c. 1850, and that at least to some extent manuscript material should be excerpted.

Place-Name Research: The work at present in progress is almost entirely confined to the four counties of Kildare, Carlow, Offaly (King's Co.) and Leix (Queen's Co.). These counties have been chosen because they cover approximately the territory of the old kingdom of North Leinster. The ultimate aim envisaged is the creation of an Archive of the place-names of the whole country, but this is a very long-term objective indeed; it is thought that by con-

fining the work to four counties there may be a prospect of publication of some results within a reasonable number of years.

The Archive would contain all existing townland, parish and barony names, all local names appearing on the Ordnance Survey maps, and as many unrecorded local names as possible, a card being made for each name. It is being divided into two sections, an Alphabetical Index, and a County Index in which duplicates of the cards in the Alphabetical Index are being arranged according to county, barony, and parish. The County Index will also contain all place-names extracted from documents, a card for each form. If these names can be identified, the cards are filed under the existing name; obsolete or unidentifiable names are filed as far as possible according to parish, barony or county.

For the four counties all names on the Ordnance maps have been entered on cards, and a few unrecorded local names have been obtained from two or three helpers in Kildare, Carlow and Leix. Names have also been extracted for the four counties from the documents of the 17th century land settlement, that is, from the Down Survey maps, the Books of Survey and Distribution, the grants made under the Acts of Settlement and Explanation, the Atlas known as Hiberniae Delineatio which was published by Petty in 1685, and the Census of Ireland said to be of the year 1659 but probably in fact of a date some ten years later. These names have been identified for Kildare, Carlow and Offaly; the work of identification of the Leix names is proceeding. At present the number of cards in the Archive is approximately 24,000.

Names received from local informants in other counties are being entered in the alphabetical index, and duplicate cards are being made and kept together for each county. Through the kindness of Dr. Cregan, Principal of St. Patrick's Training College, it has been arranged that students in the College will help in the collection of names; notebooks and maps have been supplied to several students, and three so far have sent in collections of names. Professor Delargy, Director of the Folklore Commission, has also kindly agreed to allow his collectors to help; notebooks and maps have been supplied to two of the collectors, and one of them has sent in a collection of Co. Mayo names.

In the field of Celtic Studies the work of the School was marked by the publication of a volume of Celtica dedicated to the memory of the late Richard Irvine Best to which scholars from many countries contributed articles. A second fasciculus of the Lexique Étymologique de l'irlandais Ancien was published, and a new series of the classics of Breton literature was inaugurated. M. Roparz Hemon will edit the series, and the first volume, Trois Poèmes en Moyen-Breton, has now been sent to press. In the series Scriptores Latini Hiberniae Volume IV was published and material for Volume V was sent to the printers.

3. STATUTORY PUBLIC LECTURES

Two Statutory Public Lectures were given by Professor P. Thieme (University of Tübingen), at University College, Dublin on 7th and 9th March 1961. His subject was Prehistoric Origins of Indo-European Poetry.

4. LECTURES

A lecture entitled Old Irish, the first 'modern' language in Europe was given by Professor Johannes Lohmann (University of Freiburg) at the School on Friday, 29th April 1960.

Dr. Christine Mohrmann (R.K. Universiteit, Nijmegen) visited the School in February 1961 and gave four lectures on The Latin of Saint Patrick as follows: General characteristics of the Latin of Saint Patrick (Monday, 27th February); The vocabulary of Saint Patrick (Tuesday, 28th February); The biblical element in the Latin of Saint Patrick (Thursday, 2nd March); and The Latin of Saint Patrick: general conclusion (Friday, 3rd March). These lectures are to be published and the texts were with the printer at the end of the period under review.

5. EXTERNAL ACTIVITIES

At the invitation of the Norwegian Instituttet for sammenlignende Kulturforsking (Institute for Comparative Research in Human Culture) Professor Binchy delivered four lectures in the Nobel Institute in Oslo in November 1960 on 'Insular Celtic Institutions'. He was subsequently elected Corresponding Member of the Institute. Professor Dillon attended the International Congress of Orientalists in Moscow in August 1960 and read a paper on 'The Natyasastra

in the light of Sagara's Commentary'. At the International Congress of Modern Languages and Literatures at Liège in September 1960 he read a paper on 'Prose and Verse in Irish Tradition'. Mr. Price and Professor Dillon attended a Symposium at the School of Scottish Studies in Edinburgh in November 1960. Mr. Price presented a report and Professor Dillon presided at one of the sessions. Mr. Price attended a subsequent meeting in London in January 1961 at which a permanent committee was formed. Professor Carney visited the Catholic University of America, Washington, during the period April - June 1960. While there he continued research work on the poems of Blathmac, son of Oengus, and on the Patrician problem. During that period he gave private lessons at the University on aspects of Irish literature. He attended the Thirteenth University of Kentucky Foreign Language Conference at Lexington, Kentucky (April 28-30 1961) and read a paper in the Celtic section on 'Newly discovered Irish verse of the eighth century'. He lectured in Washington and Pittsburgh on the question of St. Patrick. From June 12 to 16 he attended a Conference on Higher Education at the State University, Rutgers, New Jersey. Professor Carney also attended the Sixth International Arthurian Congress at Vannes which was held from 17 to 21 August 1960.

6. PUBLICATIONS

a. Books:

Itinerarium Symonis Semeonis ab Hybernia ad Terram Sanctam. (Scriptores Latini Hiberniae, Vol.IV) Edited by Mario Esposito. pp.x + 127 + 1 map. Price 25/- Published May 1960.

Celtica, Vol.V - Richard Irvine Best Memorial Volume. Edited by Myles Dillon. pp.x + 240 + Frontispiece + 9 plates. Price 30/- Published December 1960.

Lexique étymologique de l'irlandais ancien - MNOP. By J. Vendryes. Published jointly with the Centre National de la Recherche Scientifique, Paris, March 1961. (155 pp.) Price 21/-

Contribution à un Dictionnaire Historique du Breton, Vol.III: Biz-Ch. By Roparz Hemon. Dr. Etienne, Chateaulin, 1960.

b. Contributions to Periodicals.

D. A. Binchy: The Background of Early Irish Literature. Studia Hibernica, I, 7 - 18. 1961.

III - Report of the Governing Board of the School of Theoretical Physics adopted at its meeting on 6th July, 1961.

1. STAFF AND SCHOLARS

Senior Professors:

John L. Synge, Director of the School; Cornelius Lanczos.

Professor:

Yasushi Takahashi (appointed 1 January 1961).

Assistant Professors:

Yasushi Takahashi (to 31 December 1960);
Lochlainn Ó Raifeartaigh (appointed 1 December 1960).

Visiting Professors:

R. J. Duffin; W. Thirring.

Visiting Lecturer:

S. Kamefuchi.

Research Associates:

L. Bass (appointed 1 October 1960); D. Judge (appointed 1 October 1960).

Scholars:

A Das; G. Papini (left August 1960); Miss D. Roy (left September 1960);
C. Ryan; Rev. J. Spelman; H. Shimodaira (left September 1960);
M. O'Connell (left June 1960); P. Florides (entered September 1960).

Technical Assistant:

Miss Evelyn Wills.

2. STUDY AND RESEARCH

Professor Synge developed certain identities connected with the Einstein tensor, and used them in an iterative process for the generation of finite gravitational waves from an initial wave in the linear approximation. The convergence of certain integrals remains to be investigated. In collaboration with Mr. Das and Dr. Florides, he applied these identities to the determination, to any order of approximation, of the gravitational field of a body of any shape at rest, or of a body with an axis of symmetric spinning steadily about that axis. Professor Synge and Dr. Florides investigated weak gravitational fields with spherical symmetry in order to clarify approximate formulae connected with advance of perihelion.

Several members of the School studied a certain non-linear differential equation arising in nuclear physics, but so far it has not been decided whether there exists a solution satisfying the required conditions.

Mr. Das worked on the introduction of Dirac's field into curved space-time, and obtained a class of solutions of combined Maxwell-Einstein-Dirac field equations. He also continued, and hopes soon to complete, his work on complex space-time and the subsequent quantization involving a fundamental length.

Dr. Florides calculated the gravitational field of the rotating earth in general relativity explicitly up to the order 10^{-16}, the earth being regarded as a spheroid of small eccentricity, the square of which is not neglected. Work on the paths of satellites moving in this field is now in progress. He has also revised two papers - extracts from his Ph.D. thesis at London University - on applications of Møller's theory on energy and its localization in general relativity, and on the electromagnetic energy and the gravitational mass of a charged particle in general relativity.

Professor Lanczos approached the question of boundary value in differential operator problems from a general standpoint, and in particular studied the role of the "parasitic spectrum", with the help of explicit examples which demonstrate that the so-called "well-posed" problems can be naturally subordinated to a much wider class of problems, in which the Green's Function does not exist but it is still possible to expand the solution into the proper complete orthogonal function system. A frame of reference is thus obtained which is wide enough to include arbitrarily over-determined and under-determined systems. These investigations are incorporated in a forthcoming book on Linear Differential Operators.

In Einstein's general relativity there is a gap between the metrical tensor g_{ik} (which is of second order) and the full curvature tensor R_{ijkm} (which is of fourth order). In an investigation of the quadratic action principle of relativity Professor Lanczos has shown that there exists a tensor of third order (anti-symmetric in one pair of indices), which can serve as a "generating function" for the representation of the full Riemann tensor, in a similar way as the vector potential is able to generate the electromagnetic field strength. In the case of the Schwarzschild line-element this tensor is reducible to a mere scalar. The investigation of strong non-Einsteinian fields

is greatly facilitated by the fact that differential operators of fourth order are avoided and replaced by differential operators of not higher than second order.

The usual step-by-step integration of ordinary differential equations in numerical analysis suffers from the fact that the truncation errors tend to accumulate, with no control from our part. Although the estimated local errors remain small, the actual errors may become much larger, in view of the fact that ordinates employed in the estimation process are in themselves unreliable. In order to avoid the gradual accumulation of truncation errors, Professor Lanczos has replaced the usual local method by a global procedure which is based on the properties of the Fourier series. The errors encountered are now purely periodic and the exponential increase of errors (which characterises the local procedure) is avoided. A numerical example demonstrates in explicit form the characteristic properties of the local and the global procedure. This work was reported at the Numerical Analysis Colloquium in Mons, Belgium.

Professor Takahashi continued the work on the S-matrix theory carried out with Dr. Kamefuchi in the previous year. He extended his considerations to the case of a non-invariant S-matrix and showed that selection rules follow if the S-matrix satisfies linearly dependent relations; and, if not, the invariance is destroyed violently. Another line of research was begun on the approximation methods in meson-nucleon interactions. A new approach to this problem is proposed, namely the Hartree approximation to the meson-nucleon system, which leads us to a non-linear equation. Since it is difficult to solve it, the Ritz method was applied to evaluate the energy of the meson-nucleon system at the ground state.

Professor Ó Raifeartaigh has been considering the problem of measuring field strengths of quantized fields using quantum-mechanical test-bodies, with a view to examining the possibility of measuring the gravitational field using such bodies, and so obtaining some clue as to how the gravitational field should be quantized. This work is, as yet, only in the initial stages. He has also been engaged in developing further some work on Fermi coordinates which he carried out in this Institute some years ago. This work is concerned mainly with differential geometry, but has applications in general

relativity theory.

Professor Thirring investigated the problem of constants associated with discrete invariance groups, in view of the momentum of phonons and the theory of discrete space. He also worked out a new method in the strong coupling approximation; this will be published in the forthcoming book, "Elementary Field Theory", by E. Henley and W. Thirring.

Dr. S. Kemefuchi has made a study, in collaboration with Professor Ó Raifeartaigh, of change of variables in quantum field theory. They have found that under the most general kind of point transformation for boson fields, and a certain class of point transformation for fermion fields, the Heisenberg - Pauli formalism remains invariant, and one can get the same S-matrix before and after the transformation. On the basis of this theorem they have also discussed in a general way the equivalence theorems in quantum field theory.

Mr. Judge studied functional analysis and distribution theory, and the Jauch and Moses theories of the scattering operator.

Dr. Papini continued his study of the electromagnetic structure of the nucleon. It has been found that the proton-neutron mass difference can be explained assuming that the charge of the proton becomes negative at very short distances from the centre. Since a work in the same line has been published in the meantime by Taketani and collaborators [Progr. theor. Phys. 23, 328-52 (1960)], Dr. Papini has applied the previous results to the problem of production by scattering of electrons on protons.

Mr. Ryan continued his study of weak interactions and carried out a number of calculations on decay processes. He deduced the generalized Ward identity for the interaction of a neutral vector meson with a spinor field, and demonstrated the non-renormalisation of the vector coupling constant in β-decay. He considered problems of the axial vector coupling constant and the rate of decay of the charged pion; he derived certain identities between strong and weak interactions, and a general formula for a four fermion decay. He also began a study of the strong interactions with a view to analysing their effects on weak interactions. The various methods of solution were reviewed, and in particular a Ritz type of approximation proposed by Professor Takahashi is being examined.

Rev. J. Spelman continued his study of quantum field theory, with emphasis on the theory of scattering. He paid special attention to the electromagnetic structure of the nucleon, and, in particular, to the possibility of explaining this structure on the basis of meson field theories. Calculations are in progress which employ the idea of radiation damping and which, it is hoped, will give better agreement with experiments than the ordinary perturbation calculations.

Dr. Shimodaira pursued research, in collaboration with Professor Takahashi, on the weak coupling constant. Professor Takahashi proposed a method by which one can relate strong and weak interactions, and a number of identities were derived. The rigorous treatment of the weak coupling constant in the foundation of field theory was established, and the application to the pion-muon decay phenomena was examined.

Miss Roy made calculations on non-steady boundary layers and rotating fluids: (i) the three dimensional non-steady boundary layer, (ii) periodic boundary layer in the symmetric-axis case, (iii) boundary layer formation with constant acceleration, (iv) cylinder rotating in a fluid, (v) fluids rotating in cylindrical regions, (vi) fluids rotating between two concentric spheres.

3. SEMINARS AND LECTURES

As in previous years the seminar lectures throughout the year were attended by members of staff and students from Trinity College, Dublin, University College, Dublin, and St. Patrick's College, Maynooth, as well as by members of the School of Cosmic Physics. Starting in October, every second seminar was devoted to Elementary Particle Physics. These Seminars (marked * below) were organized by Rev. Professor J. McConnell.

The following seminar lectures were given:

*Mr. F. Anderson (University College, Dublin):
Experiments at the CERN accelerator.

Mr. A. Das:
Class of exact solutions of classical field equations in general relativity.

Dr. P. S. Florides:
The electromagnetic energy and the gravitational mass of a charged particle in general relativity.

Dr. R. C. Geary (Director, Economic Research Institute):
Some points in the theory of linear relations.

Dr. J. Hamilton (Christ's College, Cambridge):
How many elementary particles are there? (2 lectures)

*Dr. T. F. Hoang (University of California, Berkeley, and École Polytechnique, Paris):
Antiproton-proton annihilation at 1 BeV/c.

*Dr. S. Kamefuchi:
Vector field and renormalization.

Professor C. Lanczos:
The idea of a generating function in general relativity (2 lectures).

Professor F. D. Murnaghan (Consultant, U.S. Navy):
On the convergence factor for the exponential integral.

*Rev. Professor J. McConnell (St. Patrick's College, Maynooth):
Covariant statistical theory of high-energy collisions.
Production of elementary particles at CERN energies.

Professor T. E. Nevin (University College, Dublin):
Flourescence scattering of gamma rays without recoil and its applications.

Dr. F. A. E. Pirani (King's College, London):
The problem of defining energy in the gravitational field.

*Dr. N. Porter (University College, Dublin):
Nuclear interactions at very high energies.

*Mr. C. Ryan:
Recent developments in weak interaction theory.

*Rev. J. Spelman:
Electromagnetic form-factors.

Professor J. L. Synge:
Problems of general relativity (8 lectures).
Gravitational fields involving a small parameter (2 lectures).

*Dr. Ch. Terreaux (University of Liverpool):
Fröhlich's theory on elementary particles (bosons and leptons).

Professor W. Thirring:
Basic problems in quantum field theory (6 lectures).

4. STATUTORY PUBLIC LECTURE

A Statutory Public Lecture, under the auspices of the School, was delivered in Trinity College, Dublin, on 4 October 1960, by Professor Thirring. His subject was "Exploration of the sub-nuclear world".

5. VISITING PROFESSORS

Professor R. J. Duffin (Carnegie Institute of Technology, Pittsburgh) left May 1960.

Professor W. Thirring (University of Vienna) was Visiting Professor at the School from 20 August to 6 October 1960. For lectures by Professor Thirring, see sections 3 and 4.

6. VISITING LECTURERS

The following Lecturers visited the School for brief periods:

Dr. F. A. E. Pirani (King's College, London) from 1 to 6 April 1960.

Dr. J. Hamilton (Christ's College, Cambridge; now at University College, London) from 26 to 28 May 1960.

Professor F. D. Murnaghan (Consultant, U.S. Navy) 23 November 1960.

Dr. Ch. Terreaux (University of Liverpool) from 14 to 16 December 1960.

Dr. T. F. Hoang (University of California, Berkeley, and École Polytechnique, Paris) 1 March 1961.

Dr. S. Kamefuchi (Imperial College, London) was appointed Visiting Lecturer for six months from 1 December 1960.

For lectures delivered by Visiting Lecturers see section 3.

7. SYMPOSIA

Mathematical Symposia were held on 7-8 April 1960, 19-20 December 1960, and 28-29 March 1961. The attendances were respectively 55, 68, and 63; this included Professors, Lecturers, and Graduate Students from the several Irish Universities, and travelling expenses were paid to totals of £75, £95.16.8d., and £103.7.5d. respectively, including bonuses to those presenting communications in the last case.

In addition to the short communications (previews) the following lectures were delivered:

<u>April 1960</u>:

Professor Y. Takahashi: The reversibility of the process of elementary particles.

Professor J. L. Synge: Astronomical aberration in general relativity.

Dr. R. Cooper: A construction of orthogonal polynomials with peculiar asymptotic properties.

Mr. T. D. Spearman: Causality and analyticity.

Dr. S. Tobin: The Frattini subgroup of a group.

December 1960:

Dr. I. T. Adamson: The role of pure mathematics in applied mathematics.

Mr. P. Dolan: The steady state theory of cosmology.

Professor P. B. Kennedy: Short proofs.

Dr. B. H. Murdoch: Random walk.

Dr. R. McFadden: Inverse semigroups and minimal ideals.

March 1961:

Professor P. M. Quinlan: Elastic beam theory for the electronic computer.

Professor L. Ó Raifeartaigh: The Bohr-Rosenfeld investigation into the measurability of quantized fields.

Professor C. Lanczos: On "well-posed" and "ill-posed" problems.

Dr. P. D. Barry: Some theorems on minimum modulus.

Dr. J. Lewis: Semi-groups in quantum theory.

8. EXTERNAL ACTIVITIES

Professor Synge lectured at the British Mathematical Colloquium, held at Royal Holloway College (University of London) on 7 September 1960, on "Geometry and physics". He also lectured to the Liverpool Mathematical Society on 17 October 1960, on "Clocks and relativity". He was elected President of the Royal Irish Academy on 16 March 1961.

Professor Lanczos was on leave of absence from the School at the Computation Center of the University of North Carolina, from April to June 1960, where he gave a course of lectures on "Selected topics of advanced numerical analysis" (particularly interpolation and harmonic analysis). On 15 June 1960 he lectured in the mathematical seminar of the University of North Carolina on "Matrices and differential operators". He attended the Symposium on the Numerical Treatment of Ordinary Differential, Integral and Integro-Differential Equations, held at the Provisional International Computation Centre in Rome, from 20 to 24 September 1960, and gave an Invited Lecture there on 23 September on "Numerical integration of ordinary differential equations by trigonometric interpolation". On 31 January 1961 he gave a public lecture at Trinity College, Dublin, entitled "Stars and machines". From 22 to 24 March 1961 Professor Lanczos attended the Colloque sur l'Analyse Numerique, Centre Belge de

Recherches Mathematiques, at Mons (Belgium), and gave an invited lecture on "Méthodes locales et globales pour l'intégration des problèmes de trajectoires" at the Faculté Polytechnique de Mons on 23 March. He was appointed to represent the Institute on the National Committee on Mathematics.

Professor Takahashi visited the University of Liverpool from 11 to 18 October 1960. He was elected a Member of the Royal Irish Academy on 16 March 1961.

Dr. Shimodaira attended the Scottish Summer School of Theoretical Physics in Edinburgh from 1 to 20 August 1960.

Dr. Kamefuchi lectured on "Equivalence theorems and renormalisation problem in vector field theories" at the University of Birmingham on 9 December 1960.

9. PUBLICATIONS

Items marked with an asterisk were recorded as in press in previous reports.

a. Books:

(i) Published:

* Classical dynamics. By J. L. Synge. Article for Encyclopedia of Physics, Vol.3/1. Springer, Berlin, 1960. pp.1-225.

* Relativity: the general theory. By J. L. Synge. North-Holland Publishing Co., Amsterdam, 1960.

Mecânica racional. By J. L. Synge and B. A. Griffith. Translation by N. F. Furtado. Editôra Globo, Rio de Janeiro, 1960.

(ii) In the press:

* Variational principles of mechanics. By C. Lanczos. Article for Handbook of Engineering Mechanics. McGraw-Hill, New York.

* Linear differential operators. By C. Lanczos. Van Nostrand, London.

* Mechanics. Analytical dynamics. By J. L. Synge. Two articles for Collier's Encyclopedia, New York.

b. Communications of the Dublin Institute for Advanced Studies, Series A, Physics:

None published.

c. Contributions to periodicals:

(i) Published:

J. L. Synge:

* Optical observations in general relativity. Rend. Sem. Mat. Fis. Milano, 30, 1960. 35pp.

* Some properties of a world-function. Colloque sur la théorie de la Relativité, Bruxelles, 1959. Louvain, Libraire Univ., 1960. pp.25-35.

* On some special coordinate systems in general space-time. Calcutta Math. Soc. Golden Jubilee Commemoration Vol., 1958-59, Part I, 15-28.

On certain identities connected with the Einstein tensor. Proc. Roy. Irish Acad. 61A, 29-36, 1960.

How to pass to an exact solution of Einstein's vacuum field equations, starting from a linear approximation. Proc. Roy. Irish Acad. 61A, 37-44, 1961.

C. Lanczos:

Extended boundary value problems. Proc. International Congress of Mathematicians, Edinburgh, 1958. Cambridge Univ. Press, 1960. pp.154-81.

Solution of ordinary differential equations by trigonometric interpolation. Proc. Symposium on the Numerical Treatment of Ordinary Differential Equations, Integral and Integro-Differential Equations, Rome, 1960. Basel, Birkhäuser, 1960. pp.22-32.

A. J. Das:

* Spinning charged test-particles in general relativity. Progr. theor. Phys. 23, 610-15, 1960.

Cellular space-time and quantum field theory. Nuovo Cim. 18, 482-504, 1960.

* Birkhoff's theorem for electromagnetic fields in general relativity. Progr. theor. Phys. 24, 915-6, 1960.

D. Roy:

A special solution in viscous fluid motion. Mins. Proc. Roy. Irish Acad. 60, 16-18, 1960.

D. Judge, H. Shimodaira and Y. Takahashi:

On the substitution law in quantum field theory. Nuovo Cim. 16, 1139-41, 1960.

* On the substitution law in quantum field theory. Proc. Roy. Irish Acad. 61A, 45-54, 1961.

H. Shimodaira and Y. Takahashi:

Identities between strong and weak interactions. Nuovo Cim. 19, 537-45, 1961.

H. Shimodaira:

* Some remarks on fields with negative propagators in quantum field theory. Nuclear Phys. 17, 486-98, 1960.

E. Arnous, W. Heitler and Y. Takahashi:

* On a convergent non-local field theory I. Nuovo Cim. 16, 671-82, 1960.

E. Arnous, W. Heitler and L. Ó Raifeartaigh:

* On a convergent non-local field theory II. Nuovo Cim. 16, 785-805, 1960.

S. Kamefuchi and Y. Takahashi:

* Invariance and the S-matrix. Nuclear Phys. 17, 686-94, 1960.

Y. Takahashi:

Invariance and the S-matrix. II. Nuclear Phys. 20, 621-9, 1960.

L. Ó Raifeartaigh:

* The S-matrix in the non-local theory of Arnous and Heitler. Helvetica Phys. Acta 33, 783-802, 1960.

R. J. Duffin and D. H. Shaffer:

* Asymptotic expansion of double Fourier transforms. Duke J. Math. 27, 581-96, 1960.

R. J. Duffin and Z. Nehari:

* Note on polyharmonic functions. Proc. Amer. Math. Soc. 12, 110-15, 1961.

(ii) In the press:

J. L. Synge:

* Relativity based on chronometry. Monographs on Gravitation, Volume dedicated to Professor Infeld, Inst. of Theoretical Physics, Warsaw.

* Tensorial integral conservation laws in general relativity. International Colloquium on Relativistic Theories of Gravitation, Royaumont, France, 1959.

Intuition, geometry and physics in relativity. Ann. di. Mat. Rome.

C. Lanczos:

* Some properties of the Riemann-Christoffel curvature tensor. Monographs on Gravitation, Volume dedicated to Professor Infeld, Inst. of Theoretical Physics, Warsaw.

Méthodes locales et globales pour l'integration des problèmes de trajectoires (Comptes Rendus du Colloque sur l'Analyse Numerique, Mons, 1961).

Y. Takahashi:

The structure of the nucleon core by the Hartree approximation I. Nuclear Phys.

Y. Takahashi and L. Ó Raifeartaigh:

Further investigation on the non-local convergent field theory. Nuovo Cim.

IV - Report of the Governing Board of the School of Cosmic Physics adopted at its meeting on 27th June 1961.

A. Astronomical Section.

1. STAFF AND SCHOLARS

Senior Professor:

M. A. Ellison.

Chief Assistant:

J. H. Reid.

Assistant:

Vacant.

Research Assistant (Royal Society I.G.Y. Bursary):

Miss S. M. P. McKenna.

Scholar:

Ian Elliott.

Clerical and Technical Staff:

Mrs. M. Connolly; Mr. P. Murphy.

2. SOLAR RESEARCH

Drawings of the solar disk in white light were made on 43 days and observations with the spectrohelioscope on 29 days. Eleven flares were recorded, 8 of Class 1 and 3 of Class 1^-.

The radio receivers which give the integrated level of atmospherics on frequencies of 24 and 30 Kc/s were in operation throughout the year and 73 sudden enhancements of atmospherics (S.E.A's.), indicative of D-layer ionization by solar flare X-rays, were recorded. The direct recording H-magnetograph, constructed by Askania-Werke A.G. (see previous report), was brought into use on February 20. Seven solar flare effects (crochets) and 33 sudden commencements of magnetic storms were recorded (the figures given above refer to the calendar year 1960).

Papers have been published relating to (a) the spectrum of a brilliant coronal prominence following a Class 3 flare at the limb (1), and (b) the

distribution of sightline velocities in solar disk and limb phenomena (2).

3. LYOT H_α HELIOGRAPH AT THE CAPE

This instrument provides one of the most important links in the chain of stations which now maintain a continuous watch (the solar patrol) on solar activity. The solar patrol is of vital importance at the present time in view of the needs of geomagnetic, upper atmospheric and space research.

During the third year of its operation the heliograph has supplied films of chromospheric phenomena on 284 days (78 per cent of possible) with a total solar coverage of 1555 hours (calendar year 1960), as compared with 258 days and 1403 hours in 1959. Exposures were normally made at 1-minute intervals during the 7-hour (07^h00^m - 14^h00^m U.T.) daily schedule. The films were developed at the Cape and despatched weekly to Dunsink for analysis. Flares and active prominence regions have been listed and classified and the records have been sent in monthly to the Data Centres.

In all, 676 flares were counted, being rated as follows: 2 of Class 3+, 4 of Class 3, 22 of Class 2, 249 of Class 1 and 399 of Class 1^-. There were 44 examples of active prominence regions, 39 surges both limb and disk, 13 eruptive prominences and 8 disparitions brusques.

Special studies have been made of the outstanding flares on April 1 (3), June 1 (4, 5) and November 10 and 12 (7) for which good film records were available. The first of these flares accelerated into space a shower of cosmic ray protons which was recorded by the American space probe Pioneer V then at a distance of 5 million km from the earth. The November 12 flare was the first of a series of three 3+ flares (November 12, 15 and 20) associated with the same active solar region (C.M. passage November 12). All three gave rise to cosmic ray events recorded by neutron monitors at ground level, representing atmospheric bombardment by primary solar protons with energies > 1 Bev.

Three new phenomena have been detected by means of the heliograph films: (a) homologous flares, i.e. flares which occur repeatedly in the same solar active region and exhibit similar structure and development; (b) a dark halo, some 300,000 km in extent, which develops shortly after the maximum light

intensity of certain major flares that have Type IV radio emission associated with them; (c) changes in the Hα striation pattern which occur simultaneously with major flares. These features are being actively investigated in view of their importance to flare theory and to the study of solar-terrestrial relations.

A study has also been published (6) of the Hα light curves of 30 solar flares in relation to the occurrence of sudden ionospheric disturbances. An average delay of 6 minutes has been established between the time of flare maximum in Hα and the intensity peaks of the radio fade-outs and sudden enhancements of atmospherics. For geomagnetic "crochets" the time delay appears to be shorter.

4. SOLAR SPECTROGRAPH

Delivery was obtained in 1960 April of the 6-inch plane grating from the Bausch and Lomb Optical Co. and of the two 6½-inch spherical mirrors from Cox, Hargreaves and Thomson Ltd. Mountings for the various component parts were constructed in the observatory workshop and preliminary tests of the performance of the spectrograph were carried out towards the end of the year.

5. CONFERENCES AND VISITS

Professor Ellison attended the meeting of the Boyden Observatory Council held in London, July 4-5 and the meeting of the International Committee for Geophysics held in Paris, January 24-27. From September 1 to December 18 he was on leave of absence in the United States visiting, at the invitation of the Carnegie Institution of Washington, the High Altitude Observatory and the World Data Centres in Boulder. Discussions were held there on problems concerning the analysis and publication of the solar activity results amassed during the I.G.Y. Visits were also paid to the Sacramento Peak, McMath-Hulbert and Harvard Observatories to consider plans for future international co-operative programmes in solar physics.

6. ANNALS OF THE INTERNATIONAL GEOPHYSICAL YEAR

The composite drawings for the I.G.Y. Solar Map Volume (D-2) were received from the Data Centres at Boulder, Freiburg and Sydney. This completes the

material needed for the printing of the multicolour maps of the sun, consisting of records of sunspots, prominences, coronal isophotes and radio heliograms for each of the 549 days of the I.G.Y. The work has been in the charge of the Freiburg Centre and all the drawings were checked and arranged at Dunsink before despatch to the Pergamon Press. It is hoped that the printing will be completed before the end of 1961.

Similar drawings in connection with the D-1 Volume were received for the first 9 months of the I.G.Y. These colour maps will show sunspots, calcium plages, flares and limb and disk surges. The work has been in charge of the Boulder Centre with contributions from Arcetri, Meudon and Zürich.

Drawings for the volume of Sunspot Magnetic Field Maps, covering the first 9 months of the I.G.Y. were received from the Data Centre at the Crimean Astrophysical Observatory.

7. LIBRARY

Further progress has been made with arrears of binding. Some 127 volumes have been bound of those periodicals which are most consulted.

8. STAFF AND VISITORS

There were no changes of staff during the year.

The Observatory has been open to the public on the first Saturday of each month from September to April. The 12-inch South refractor was available to members of the Dublin Centre of the Irish Astronomical Society. Visiting scientists included Professor E. J. Conway, Professor E. T. Copson and Dr. S. F. Smerd.

9. PUBLICATIONS

The numbering corresponds with the references in the various sections of the Report.

Contributions to Periodicals:

(1) Ian Elliott, M. A. Ellison and John H. Reid:

Spectra of a Bright Coronal Prominence associated with a Class 3 Flare. Monthly Notices of the Royal Astronomical Society, 121, 463, 1960.

(2) John H. Reid:

Distribution of Sightline Velocities in Solar Disk and Limb Phenomena. Journal of the British Astronomical Association, 70, 123, 1960.

(3) M. A. Ellison, Susan M. P. McKenna and J. H. Reid:

The Solar Flare of 1960 April 1. The Observatory, 80, 149, 1960.

(4) M. A. Ellison, Susan M. P. McKenna and J. H. Reid:

The Solar Flare of June 1, 1960. Nature, 187, 926, 1960.

(5) M. A. Ellison, Susan M. P. McKenna and J. H. Reid:

The 3+ Flare of 1960 June 1 and its influence on the Hα Striation Pattern. Dunsink Observatory Publications, 1, 39, 1960.

(6) M. A. Ellison, Susan M. P. McKenna and J. H. Reid:

Light-curves of 30 Solar Flares in relation to Sudden Ionospheric Disturbances. Dunsink Observatory Publications, 1, 1, 1960.

In course of printing:

(7) M. A. Ellison, Susan M. P. McKenna and J. H. Reid:

Flares associated with the 1960 November Event and the Flare Nimbus Phenomenon. Monthly Notices of the Royal Astronomical Society.

(8) M. A. Ellison (Editor):

Daily Maps of the Sun for each day of the International Geophysical Year (Volumes D-1 and D-2). Annals of the IGY. Pergamon Press.

B. Cosmic Ray Section.

1. STAFF AND SCHOLARS

Senior Professor:

C. Ó Ceallaigh.

Professor:

Vacant

Assistant Professors:

R. H. W. Johnston (to 1 October 1960); K. Imaeda.

Technical and Clerical Staff:

Miss C. Inight, Mr. J. Daly, Miss N. Leahy, Miss M. McGovern, Miss P. Cully, Miss M. Longmore, Miss E. Smith.

Scholars:

Miss M. Kazuno; K. Halpenny; A. Thompson; J. Avidan.

Visiting Physicists:

E. Page; Z. Osborne.

2. RESEARCH WORK

Schein Stack: The division of material from the Schein Stack referred to in last year's Report has taken place, and work is in progress on the study of interactions of extreme high energy which occur in the portion of the stack allocated to the School. This valuable material has been given gratis, and it is appropriate to record our indebtedness to the promotors of the enterprise, and to pay tribute to the memory of the late Professor M. Schein of the University of Chicago, through whose efforts the project was conceived. The work is being done on the basis of collaborative effort in which physicists from the following Institutions are taking part: Università di Parma, Parma; Instituto di Fisica, Università di Padova; Università degli Studi di Bari, Bari; Università di Genova; Instituto di Fisica, "Gugliemo Marconi", Rome; Università di Torino, Turin; Akademia Gorniczo-Hutnicza, Krakow, Poland; Institut für Theoretische Physik, Vienna; Institut für Experimentalphysik, Hamburg; Max Planck Institut für Physik, Munich; Institut für Reine und Angewandte Kernphysik, Kiel; Dublin Institute for Advanced Studies, 5 Merrion Square, Dublin; Universitetet i Oslo, Blindern; Weizmann Institute of Science,

Rehovoth, Israel; H. H. Wills Physics Laboratory, University of Bristol.

The paper on the Ionization-Velocity Relation in Photographic Emulsion for singly-charged particles (Johnston, Prowse and Shaukat) has now been submitted for publication. Discussions for continuation of this work have been held with interested physicists, and it is proposed that further plates be exposed at the CERN machine on behalf of a group at the University of Bristol, working in collaboration with a group from this School. Unfortunately, owing to unavoidable changes in the machine schedule, it has been necessary to postpone this work. It is expected that the exposures will take place in the Autumn of 1961.

During the session Professor R. H. W. Johnston was engaged in investigating the possibility of constructing a machine for measuring ionization by a semi-automatic method. The parameter chosen was the mean gap-length which had previously been shown by Ó Ceallaigh and verified by other workers to be largely independent of conditions of development in the emulsion. Professor Johnston has succeeded in devising what appears to be an ingenious and promising method and a preliminary report on the proposal has been drawn up by him. Unfortunately, however, it has not proved possible at present to proceed with the development of his scheme owing to the demands on our resources by current research projects.

A preliminary report on the search for D^+ -particle of supposed mass 1400 me and of strangness 2 has been prepared. No evidence for the existence of this particle was obtained and the form of publication of the work is at present under discussion.

A continuation of the work of Alexander, Johnston and Ó Ceallaigh on the Relative Frequencies of K^+ Meson Decay Modes and the $K_{\mu 3}$, K_{β} and $K_{\pi 3}$ Decay Spectra has been completed and, at present, is in preparation for publication. In carrying out computations involved in this work, use was made of the Computer of the Irish Sugar Company at their Thurles Factory. These facilities were made available to us through the courtesy of the General Manager, Lt. General Costello, and it is a pleasure to record our gratitude for this useful favour.

Cosmic Ray Time Variations Experiment: During the period the Dublin station has continued to co-operate with those in Sydney and Jamaica where some interest has been shown in nuclear emulsion investigations. On the other hand, the apparatus in Dublin has remained, in essence, that as reported during 1959-60.

The arrival times and arrival directions of extensive air showers have been further investigated using Wilson Cloud Chambers and Geiger counters. Particular attention was paid to the solar time variations of those showers of very high electron density. The amplitude of this semi-diurnal oscillation would now appear to vary with sunspot cycle and with the seasons. During the five years since 1955, summer amplitudes have always been greater than those recorded in winter. Maximum average shower density is always found when the collecting rate is a minimum. This observation would suggest that there is a periodic variation in shower structure - perhaps due to the periodic change in interaction height of heavy primaries.

The most interesting result, accepted in November 1960 for publication in Proceedings of the Physical Society, has been connected with the shower frequency-density spectrum. In the past the number of showers with density e has been represented by $n(e) \alpha e^{-\gamma-1}$, with $\gamma = 1{\cdot}5$ for all values of e. Using geiger techniques, some workers found that $\gamma = 1{\cdot}4$ at low e values. At higher densities, where geiger measurements are not possible, owing to saturation, investigation with proportional counters gave $\gamma \simeq 2{\cdot}5$. On account of the different techniques employed there existed some doubt as to the reality of the apparent difference in slope. However, using Cloud Chambers to study the whole range of particle density, it has been found in Dublin that, in fact, γ changes from 1·5 to approximately 2·9 at densities around 600 particles per metre^2. If this change is real (and not due to Wilson Cloud Chambers inefficiency at high e) the result has a direct bearing on the important problem of the origin of high energy cosmic radiation.

3. COMMITTEES

N.I.R.N.S., Harwell: Professor Ó Ceallaigh was invited to act as a member of the British Emulsion Committee. The purpose of this body is to

consider what type of experiments it will be profitable to carry out at the 7 Gev Proton Synchrotron which is being built at the Rutherford Laboratory of the national Institute for Research in Nuclear Science (N.I.R.N.S.) at Harwell, Berks., England. During the year, he attended several meetings at Harwell and Geneva. It is expected that this accelerator will come into operation in 1963.

CERN, Geneva: Following administrative reorganisation, the unofficial advisary committee has been constituted an official body with the title CERN Emulsion Experiments Committee. The Chairman is Professor C. F. Powell, F.R.S. of the University of Bristol. This Committee is made up of some 15 representatives of the emulsion groups active in the member States. In addition, certain people have been coopted to represent those groups active in the non-member States. Professor Ó Ceallaigh has been coopted a member to represent the Republic of Ireland. He has attended several meetings of this body and has made arrangements to take part in several experiments which will be carried out in collaboration during the next two years.

In this connection it seems appropriate to draw attention to the very helpful and generous attitude of both the British physicists and of the authorities of CERN in giving representation to the Irish Republic on bodies associated with projects towards the finances of which the State has made no contribution.

Professor K. Imaeda and Miss M. Kazuno attended meetings at the University of Bristol to arrange for the apportionment of the plates from the Schein Stack and to discuss details of the Collaboration.

4. SEMINARS AND VISITORS

The following are the titles and authors of talks given in the Section during the Financial Year 1960-61:

Professor M. Kaplon (University of Rochester, N.Y., U.S.A.) 23 May, 1960:
γ-Ray Astronomy.

Dr. W. O. Lock (CERN, Geneva) 27 September, 1960:
The Interactions of Pions and Protons of Energy 14-24 Gev with Nucleons and Nuclei.

5. STATUTORY PUBLIC LECTURE

A Statutory Public Lecture, under the auspices of the School, was delivered in University College, Dublin, on 26 January 1961, by Professor B. Peters (Universitetets Institut for Teoretisk Fysik, Copenhagen). His subject was "Cosmic Ray produced Isotopes in Geophysical Research". Professor Nevin kindly presided and introduced the Speaker.

6. INSTRUMENTS AND WORKSHOP

Mr. Daly has continued to service the existing instruments and to help occasionally in the maintenance of the counter and cloud-chamber equipment of the time-variations experiment. He has attended the Exhibition of Scientific Instruments organised by the Physical Society and visited the National Physical Laboratory at Teddington, Middlesex.

One new Cooke M.4000 microscope has been acquired for the Section and a Leitz Ortholux microscope with a special Stodiek Scattering stage has been ordered and will be delivered in the late Autumn of 1961.

7. PERSONAL

The following Scanners resigned their posts during the year: Miss D. Kelly (30 September 1960); Miss C. Duff (30 September 1960); and Miss P. Hayden (30 September 1960). The following were appointed to the vacant posts: Miss M. McGovern (10 October 1960); Miss P. Cully (10 October 1960); and Miss M. Longmore (9 November 1960). Professor R. H. W. Johnston resigned his post as Assistant Professor in the School on 30 September 1960 to take up an appointment with Messrs. A. Guinness & Sons, Park Royal, London. Dr. Z. Osborne of the University of Oklahoma came to the School on 6 March 1961 as a visiting scientist. He holds a Fellowship. Mr. K. Halpenny, Queen's University, Belfast (7 November 1960), Mr. A. Thompson, Trinity College, Dublin (1 December 1960), and Mr. J. Avidan, Weizmann Institute, Rehovoth (16 January 1961) took up tenure of their Scholarships on the given dates. The total of staff and students now engaged on research in the Section numbers 7, and the total personnel is 16. This is the largest number ever to work in the Section

and is such that overcrowding has become serious. Without the provision of additional accommodation it will not be possible to expand the Section, and it will be necessary to consider carefully what is to be our future policy.

8. PUBLICATIONS

C. B. A. McCusker, D. E. Page and R. J. Reid:

The Solar Variation in Rate of Extensive Air Showers. Proc. Moscow Conf. 111, 281, 1960.

R. J. Reid, K. Gopaulsing, D. E. Page, M. Idnurm, C. B. A. McCusker, J. Malos, D. D. Millar and G. Winterton:

The Differential Electron Density Spectrum of Air Showers at High Densities. (Accepted by Proc. Phys. Soc. London, Nov. 1960).

R. H. W. Johnston and M. A. Shaukat (Dublin Institute for Advanced Studies) and D. Prowse (University of California, Los Angeles):

The Ionization-Velocity Relation for Singly-Charged Particles in Photographic Emulsions. (Submitted for publication to Nuovo Cimento).

In preparation:

R. H. W. Johnston:

Preliminary Report on the Dublin 'Semi-Automatic Mean Gap-Length Measuring Instrument.'

C. Geophysical Section.

1. STAFF AND SCHOLARS

Senior Professor:

Leo W. Pollak.

Professor:

Thomas Murphy.

Research Assistant:

Arvids Leons Metnieks (under U. S. Air Force and U. S. Army Contract).

Research Associate:

Rev. G. McGreevy.

Senior Technical Assistant:

Thomas J. Morley.

Technical and Clerical Staff:

Miss Nessa Falconer; Miss Margaret Ryan (resigned 31 August 1960); Miss Brenda Kennedy (entered 1 December 1960); Mr. Kevin Bolster; Mr. Martin Cotter.

2. INVESTIGATIONS, EXPERIMENTAL AND FIELD WORK

a. Professor L. W. Pollak and Co-workers:

The paper 'Experiments with condensation nucleus size spectrometers' (Rich and Pollak and Metnieks, Reference iv in Section 3, Publications) presents the theory of an electrical method for resolving a polydisperse aerosol, brought up to charge equilibrium, using Boltzmann's law of charge distribution and reports on experimental tests of this method and on a comparison of its results with those obtained by the Pollak-Metnieks exhaustion method employing a diffusion battery without end-pieces or connecting tubing.

The resolution of polydisperse aerosols by determining the mobility spectrum of the charged components of the aerosol, brought up to charge equilibrium, showed that the electrical method is well suited for nucleus populations with a large percentage of charged nuclei (rather big nuclei) and is sensitive enough to indicate the ageing, even over a few hours, of a stored aerosol. The equivalent radius, as computed from the concentrations of the charged and uncharged nuclei of an aerosol under charge equilibrium conditions,

agrees very well indeed with the average radius of the size spectrum, determined by the electrical method, and represents so far the best single characteristic of a polydisperse aerosol.

The results obtained up to now by the electrical and exhaustion method (based on the dynamic method as introduced by J. J. Nolan and Guerrini) are in good agreement both with regard to the spectral distribution of the components and to the average size of the nuclei.

A. L. Metnieks suggests in Ref.v (Section 3) a modification of the dynamic method which permits determining the diffusion coefficient of an aerosol from two concentration measurements at the exit of a diffusion battery with different air-flows instead of measuring the concentration at the entrance and that at the exit as originally employed.

The influence of pressure on the counting of condensation nuclei has been investigated by Pollak and Metnieks (Ref.vi in Section 3). They deal with the influence of the expansion ratio applied in the counting instrument and with a phenomenon called the Schlarb effect according to which the counts of nuclei made at a reduced pressure are considerably lower than the expected concentration computed from the pressure ratio. Experiments with a container of 283 litres showed that when the pressure is lowered to half, the reduction produced by this effect increases with increasing concentration. For concentrations between 20000 and 45000 nuclei/cm^3 the average percentage reduction of the expected concentration amounts to 52%. The experiments by Pollak and Metnieks proved also that at the lower pressure the nuclei not counted are present.

Ways of eliminating the Schlarb effect are suggested.

The world-wide use of our photo-electric nucleus counter (School of Cosmic Physics Model 1957) often under conditions very different from those under which the instrument was calibrated in 1959 and 1960, necessitated an investigation into the influence of temperature on the counting of condensation nuclei with this instrument. In the paper: The influence of pressure and temperature on the counting of condensation nuclei, Part II: Influence of low temperature (Pollak and Metnieks, Ref.i in Section 3, In Course of Printing) the dependence of extinction on low temperature down to $-7^{\circ}C$ is examined and a definite relationship was found. The effect of a

cooling and re-heating cycle on an aerosol and the elimination of the temperature effect on the counting of nuclei with a photo-electric counter is discussed.

In order to facilitate the application of condensation nucleus size spectrometers, extensive tables have been computed (Metnieks and Pollak) which, together with graphs, are in course of publication as Geophysical Bulletin No.19.

A bigger model of the ice-nucleus cloud chamber for studying the behaviour of ice nuclei, described in last year's annual report, has been constructed in the workshop of the Section and its properties studied. A paper on our construction and its test is in preparation.

We have been investigating for some time the application of Boltzmann's distribution law to the concentrations of charged and uncharged nuclei with radii in the region of 1. 10^{-6} cm.

The equipment for studying the equilibrium of ionization in air has been procured or constructed in the workshop of the Section. The General Electric, Schenectady, N.Y. has supported this research by presenting to the Section instruments and material amounting to $500 and put a further $1000 at our disposal for this investigation until a new contract with Professor Pollak will be made.

The research reported above has been supported in part by the Geophysics Research Directorate of the United States Air Force, the U.S. Army Research and Development Liaison Group and the General Electric Co., Schenectady, New York.

b. Professor Murphy:

The readings of gravity were extended over Counties Meath and Westmeath and it is now fairly well established that there is little variation in density throughout the palaeozoic series of rocks in Ireland with the exception of granite. Hand specimens of rocks confirm this but the latter method is severely limited. Thus the variations of gravity in the southern part of Ireland, south of Galway-Dundalk, are related more with large differences in thicknesses of the various rocks. From this it is possible to draw conclusions concerning the structure of the earth's crust and a paper on this subject is in preparation.

In view of the theories of Beloussov and of those of continental drift the extension of gravity readings beyond the borders of Ireland is highly desirable. Discussions on these lines are taking place with interested parties in England and it is hoped we can combine with a group who are planning measurements off the Welsh coast so that we can elucidate the problem of the structure of St. George's Channel.

The measurement of the densities of various rocks is being continued. As unweathered samples only are of value these are being obtained from borings and from working quarries. The Geological Survey and various mining and prospecting concerns are very helpful to us in this.

Detailed gravity measurements were taken in Co. Monaghan and in the border region of the Six Counties. This work was carried out jointly by the Geological Survey of Great Britain and this Section. An important discovery concerning Lough Foyle has resulted from this co-operation.

An opportunity was afforded to us to visit and have discussions with members of Seismograph Services Ltd. while they were carrying out seismic work across the Dungiven-Ballycastle gravity feature discovered in our earlier surveys. As expected, great difficulties were encountered and as yet their analysis is not complete to compare with our findings.

On working up the gravity readings taken in Counties Meath and Westmeath several values were obtained which were considerably lower than expected. The differences are outside the limits of error and in several cases remeasurements have shown them to be real. A few had already been encountered elsewhere. The phenomenon is, as yet, not explained and detailed work is being carried out.

The South of Ireland Exploration Company sought assistance to help them explain some Spontaneous Polarisation results they obtained during their prospecting in Co. Wexford. Although the work seems very interesting and some assistance was offered, no field work could be undertaken owing to lack of staff. There is plenty of room for research, both practical and theoretical, in this field as very little scientific work, as distinct from prospecting, has been carried out. In return for what assistance they obtained, the company have helped in allowing us access to certain geophysical information obtained in Co. Wexford.

J. B. Prendergast of the Northgate Exploration Co. Ltd., Toronto called for discussions regarding the gravity work in Co. Clare.
G. Törnquist of the AB Elektrisk Malmletning Co., Sweden, also called for information.

The Land-Rover car has been put into commission to replace the Ford Van presented in 1949, by Messrs. A. Guinness. It is proving most convenient for gravity work so that an additional part of the country will now be more accessible for gravimeter readings.

c. Research Associate Rev. G. McGreevy:

Fr. McGreevy is studying in St. Patrick's College, Maynooth the change of particle size and composition of an ageing aerosol stored in a balloon gasometer using the exhaustion method.

3. PUBLICATIONS

i L. W. Pollak and A. L. Metnieks:
Intrinsic calibration of the photo-electric condensation nucleus counter, Model 1957 with convergent light-beam.
Technical (Scientific) Note No.9, Contract USAF 61(052)-26, Dublin 1960. 62 pp.

ii T. Murphy:
Gravity Anomaly Map of Ireland, Sheet 5 - South West.
Geophysical Bulletin No.18 of the Meteorological and Geophysical Section, School of Cosmic Physics. Dublin 1960.

iii T. Murphy:
The computation of gravity differences from observations with a Worden gravimeter and the resultant errors.
Geofisica Pura e Applicata, Milano, Vol.45, 1960. pp.27-39.

iv T. A. Rich, L. W. Pollak and A. L. Metnieks:
Experiments with condensation nucleus size spectrometers.
Ibidem, Vol.46, 1960. pp.145-163.

v A. L. Metnieks:
A modification of the dynamic method for determining the diffusion coefficient of aerosols.
Ibidem, Vol.46, 1960. pp.164-166.

vi L. W. Pollak and A. L. Metnieks:
The influence of pressure and temperature on the counting of condensation nuclei, Part I: Influence of pressure.
Ibidem, Vol.47, 1961.

In Course of Printing:

i L. W. Pollak and A. L. Metnieks:
The influence of pressure and temperature on the counting of condensation nuclei, Part II: Influence of low temperature.
Geofisica Pura e Applicata, Milano, Vol.48, 1961.

ii A. L. Metnieks and L. W. Pollak:
Tables and graphs for use in aerosol physics, Part I.
Geophysical Bulletin No.19 of the Meteorological and Geophysical Section, School of Cosmic Physics. Dublin 1961.

In Preparation:

i L. W. Pollak and A. L. Metnieks:
On the validity of Boltzmann's law for small condensation nuclei.

ii L. W. Pollak and A. L. Metnieks:
A cloud chamber for synchronous determination of ice-nucleus concentration at various temperatures.

iii T. Murphy:
The structure of the earth's crust under southern Ireland according to gravity data.

4. U. S. AIR FORCE CONTRACT AF 61(052)-26 and Supplemental Agreements 1 to 3.

The contract has been extended up to 31st October 1961.

5. U. S. ARMY CONTRACT DA - 91 - 591 - EUC - 1282

The contract has been renewed for a second year until 30th November 1961 (DA - 91 - 591 - EUC - 1657).

Colonel R. K. Saxe, Ph.D. of the European Research Office, U.S. Department of the Army, Frankfurt a.M. visited the Section on 13th December 1960.

6. COLLABORATION WITH RESEARCH LABORATORY OF GENERAL ELECTRIC COMPANY IN SCHENECTADY, NEW YORK

On the invitation of the U.S. General Electric Company, Professor Pollak had consultations in the Research Laboratory of the firm in Schenectady, N.Y. during his visit from September 13 to October 16, 1960. A plan for further collaboration on problems of common interest has been drawn up, in which the specialised equipment of the Section, not available elsewhere, will be used.

No expenditure whatsoever has been incurred by the Institute in connection with this visit.

7. METEOROLOGICAL AND GEOPHYSICAL SEMINAR

25th April 1960: Privatdozent Dr. H. W. Georgii, University of Frankfurt am Main: New results concerning the Austausch-mechanism.

26th and 27th April 1960: Privatdozent Dr. H. W. Georgii, University of Frankfurt am Main: Cloud physics and precipitation mechanism.

MISCELLANEOUS

(i) During his visit to the United States of America from September 13 to October 16, 1960 Professor Pollak (See Section 6) had discussions also at the Geophysics Research Directorate of the United States Air Force in Bedford, Mass. with Dr. C. Junge and Dr. S. J. Birstein, the previous and present project scientists in charge of our U.S. Air Force Contract and, on invitation, at the School of Public Health of Harvard University in Boston which is interested in our diffusion battery without end-pieces or connecting tubing and other constructions of ours. Here Professor Pollak was shown a very large diffusion battery having end-pieces, whose volume can be continuously changed with the aid of precision rack and pinion. The cost of this apparatus is estimated at $5000 and is to-day obsolete, since it is superseded by the diffusion battery without end-pieces constructed in the workshop of the School (L. W. Pollak and J. Daly).

In a letter dated 18th October 1960, Mr. R. A. Gussman, Department of Industrial Hygiene, Harvard School of Public Health, Boston, informed Professor Pollak that the Director, Dr. Silverman, Consultant to the United Stated Atomic Energy Commission and Mr. Billings have decided to construct two exact copies of the School of Cosmic Physics photo-electric nucleus counter Model 1957 as per the 1960 calibration. We have supplied the workshop drawing of the instrument and all our publications on this and other constructions of the Section.

(ii) Professor Pollak attended the morning session of the one-day symposium on "Airborne contamination and its control" held in Schenectady, New York on October 6, 1960.

(iii) To the Physical Science Laboratory of the U.S. Weather Bureau, Washington D.C., who intend to make for their purposes a copy of our photo-electric nucleus counter Model 1957, we supplied, on request, our workshop drawing and our relevant publications.

(iv) The following scientists have visited our laboratory in order to familiarise themselves with our work in aerosol physics:

(a) Dr. J. McK. Ellison, Medical Research Council, Group for Research on Atmospheric Pollution, St. Bartholomew's Hospital, London, on 18th May 1960.

(b) Mr. C. M. Taylor, Assistant Director Research, East Africa Meteorological Department, Nairobi, on 23rd and 25th June 1960.

(c) Dr. P. K. Mueller, Research Chemist, State of California Department of Public Health, Berkeley, Cal., U.S.A., on 1st August 1960.

(d) Professor R. Dennis, Department of Industrial Hygiene, School of Public Health, Harvard University, Boston, Mass. from 12th to 15th December 1960.

(e) Dr. W. Schulz, Meteorological Institute of the Technical University, Karlsruhe, West-Germany, from 7th to 11th March 1961. Dr. Schulz brought with him a copy of the School of Cosmic Physics photoelectric nucleus counter, Model 1957, made according to our specification in Karlsruhe, for standardisation.

EDWARD J. CONWAY
CHAIRMAN

26 January 1962